A comparison of finite element implementation of Cosserat and strain-gradient plasticity models for predicting localisation

F. Gulib*, S.-A. Papanicolopulos†

*School of Engineering
The University of Edinburgh
Alexander Graham Bell Building, The King's Buildings, EH9 3JL, Edinburgh, UK
E-mail: f.gulib@ed.ac.uk

† School of Engineering
The University of Edinburgh
William Rankine Building, The King's Buildings, EH9 3JL, Edinburgh, UK
Email: S.Papanicolopulos@ed.ac.uk

ABSTRACT

Classical plasticity models are not equipped with any internal length and are therefore unable to describe phenomena such as size effects and strain-localisation. They also give rise to pathological mesh dependency of numerical finite element results at the onset of material softening. To overcome these deficiencies, models such as strain-gradient and Cosserat plasticity have been proposed in the literature. However, there is a lack of comparative studies of these models and their numerical implementation, for example with respect to their ability to predict localisation behaviour, especially for two- and three-dimensional problems.

This work compares the numerical implementation (in a commercial finite element code) of some existing strain-gradient [1, 2] and Cosserat [3, 4] plasticity models. The two-dimensional (plane strain) problem of biaxial compression is considered for the study of localisation effects due to material strain-softening. We thus provide guidance on the applicability of these models in plasticity problems in terms of material parameters requirement, ease of numerical implementation, computational cost and their behaviour in the subsequent evolution of the localized plastic zone.

ACKNOWLEDGEMENTS

This research effort is funded from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme (FP7/2007-2013) under REA grant agreement nº 618096.

REFERENCES

[1] N.A. Fleck, J.W. Hutchinson, "Strain gradient plasticity", In: J.W. Hutchinson, T.Y. Wu, (Eds.), Advances in Applied Mechanics*, vol.* ***33***, Academic Press, New York, 295–361 (1997).

[2] A. Zervos, P. Papanastasiou, I. Vardoulakis, "A finite element displacement formulation for gradient elastoplasticity", *International Journal for Numerical Methods in Engineering*, ***50***, 1369–1388 (2001).

[3] R.D. Borst, "A generalization of J_2-flow theory of polar continua", *Comp Method in Applied Mechanics and Engineering*, ***103***, 347-362 (1993).

[4] H. Arslan, S. Sture, "Finite element analysis of localisation and micro-macro structure relation in granular materials. Part I: Formulation", *Acta Mech*, ***197***, 135-152 (2008).